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Title: An Algorithmic Overview of TRANSIMS

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An Algorithmic Overview of TRANSIMS

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Los Alamos National Laboratory
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Abstract

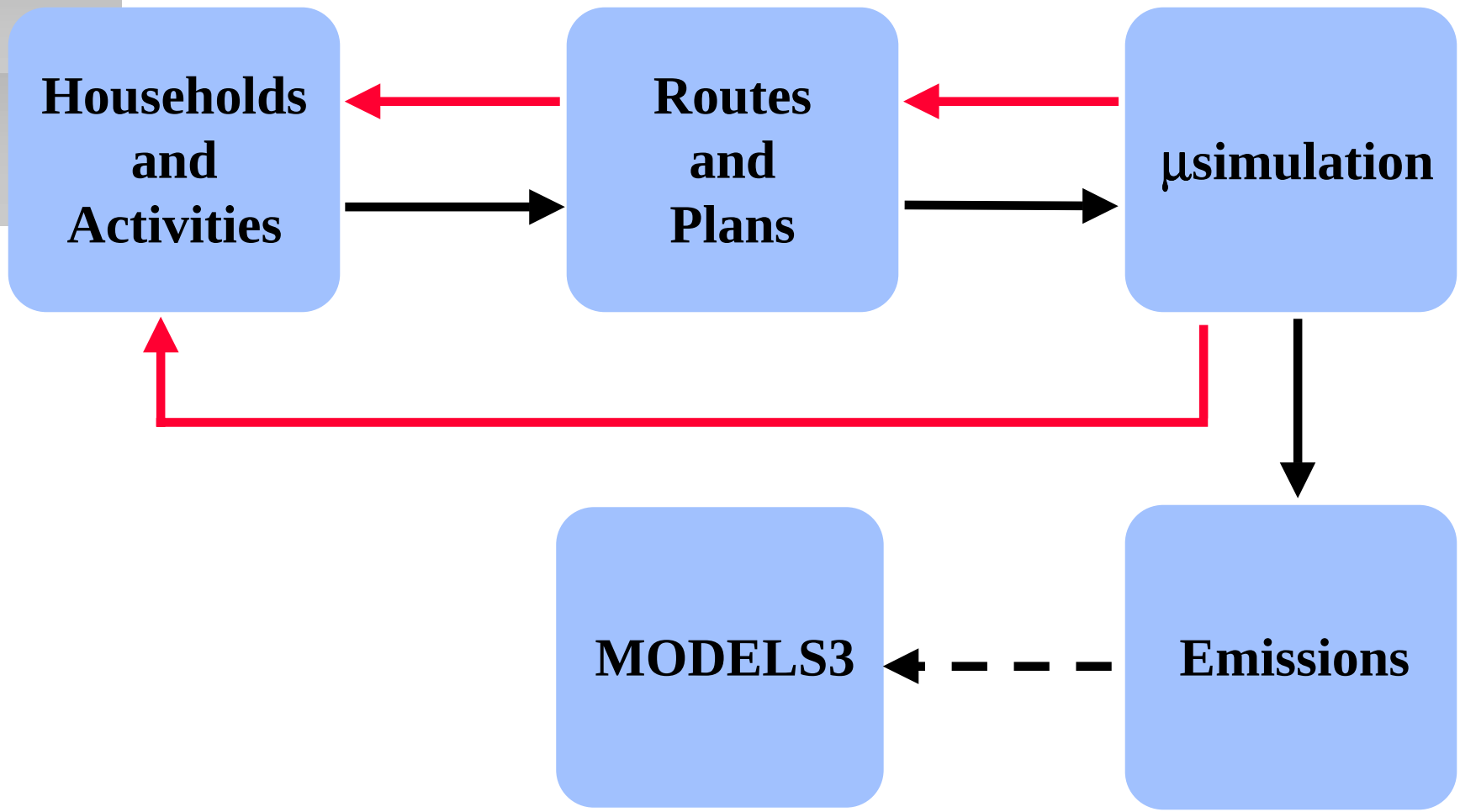
TRANSIMS (Transportation Analysis and Simulation System) is an integrated system of travel forecasting models designed to give transportation planners accurate, complete information on traffic impacts, congestion, and pollution. The underlying TRANSIMS philosophy is that individual behaviors and their interactions, as constrained by the transportation system, generate the transportation system's performance. To effect that performance in a simulation, individual behavior must be modeled. This presentation provides an overview of the algorithms used in TRANSIMS.

Los Alamos National Laboratory is leading this effort to develop these new transportation and air quality forecasting procedures required by the Clean Air Act, the Intermodal Surface Transportation Efficiency Act, and other regulations; it is part of the Travel Model Improvement Program sponsored by the U.S. Department of Transportation, the Environmental Protection Agency, and the Department of Energy.

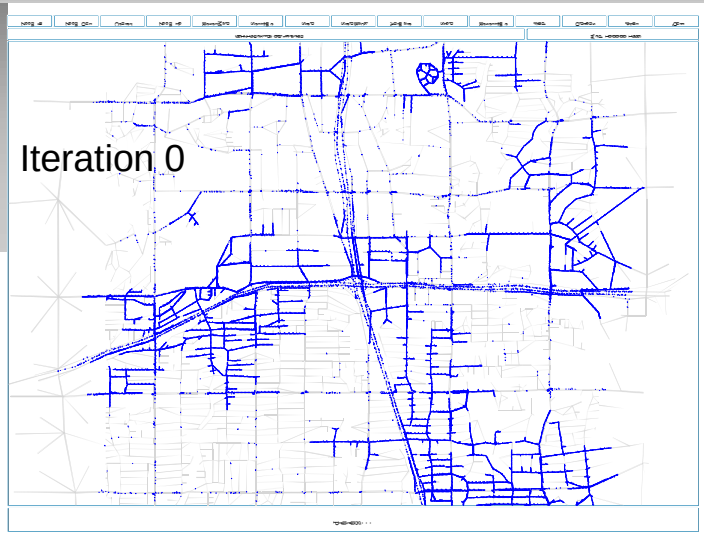
TRANSIMS Approach

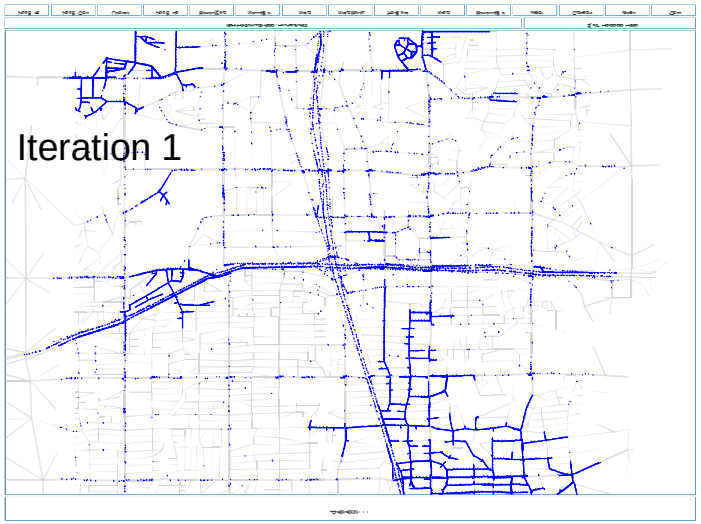
- *virtual metropolitan region created comprising complete representation of a region's . . .*
  - *individuals*
  - *activities*
  - *transportation infrastructure*
- *trips planned to satisfy individuals' activity patterns*
- *movement of individuals across transportation network simulated on a second-by-second basis*
  - *realistic traffic dynamics produced from interactions of individual vehicles*
  - *vehicle pollutant emissions and fuel consumption estimated*
- *models iterated*
  - *stabilizes simulation*
  - *allows travelers to react to information about the satisfaction of their preferences*

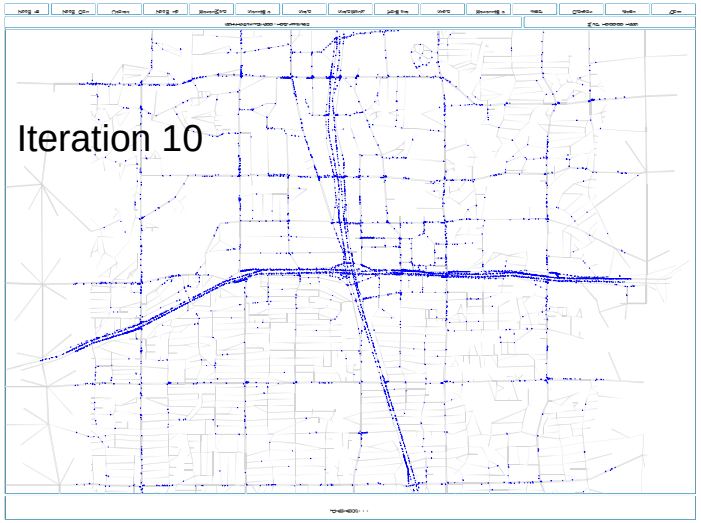
Major TRANSIMS Components



Iteration and Feedback in TRANSIMS



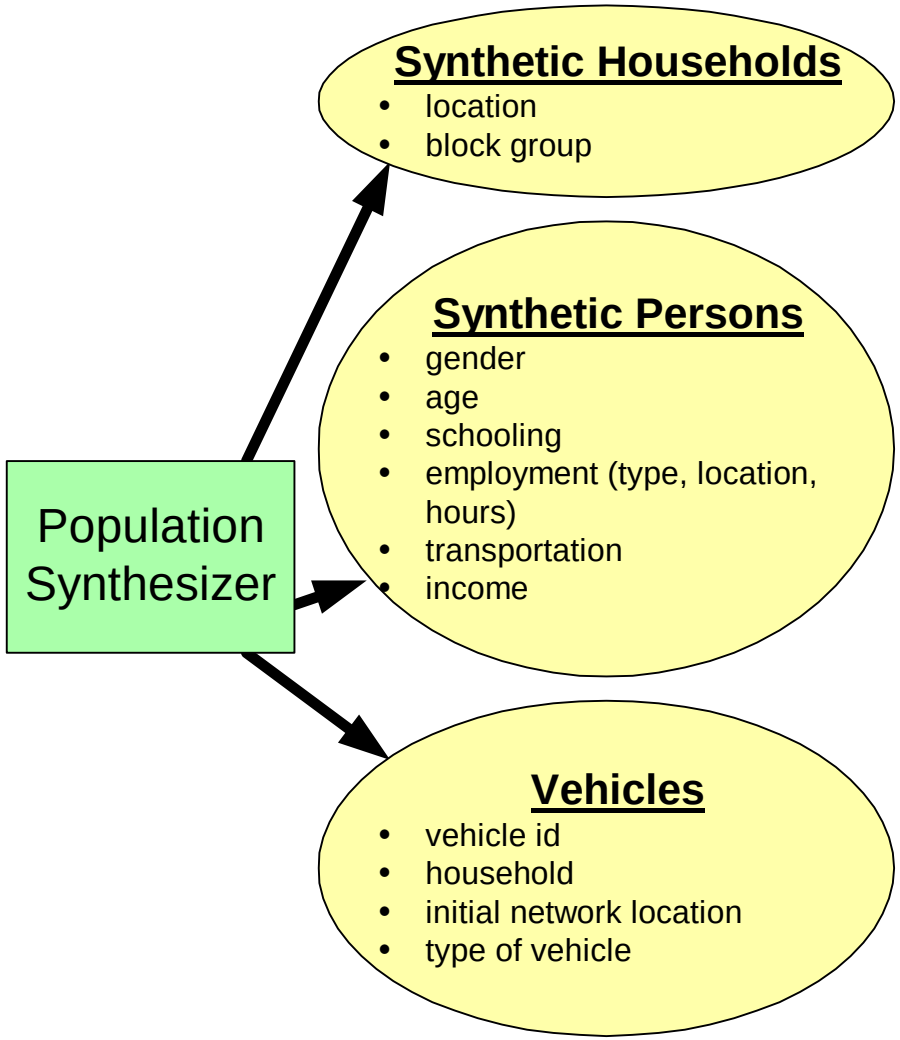




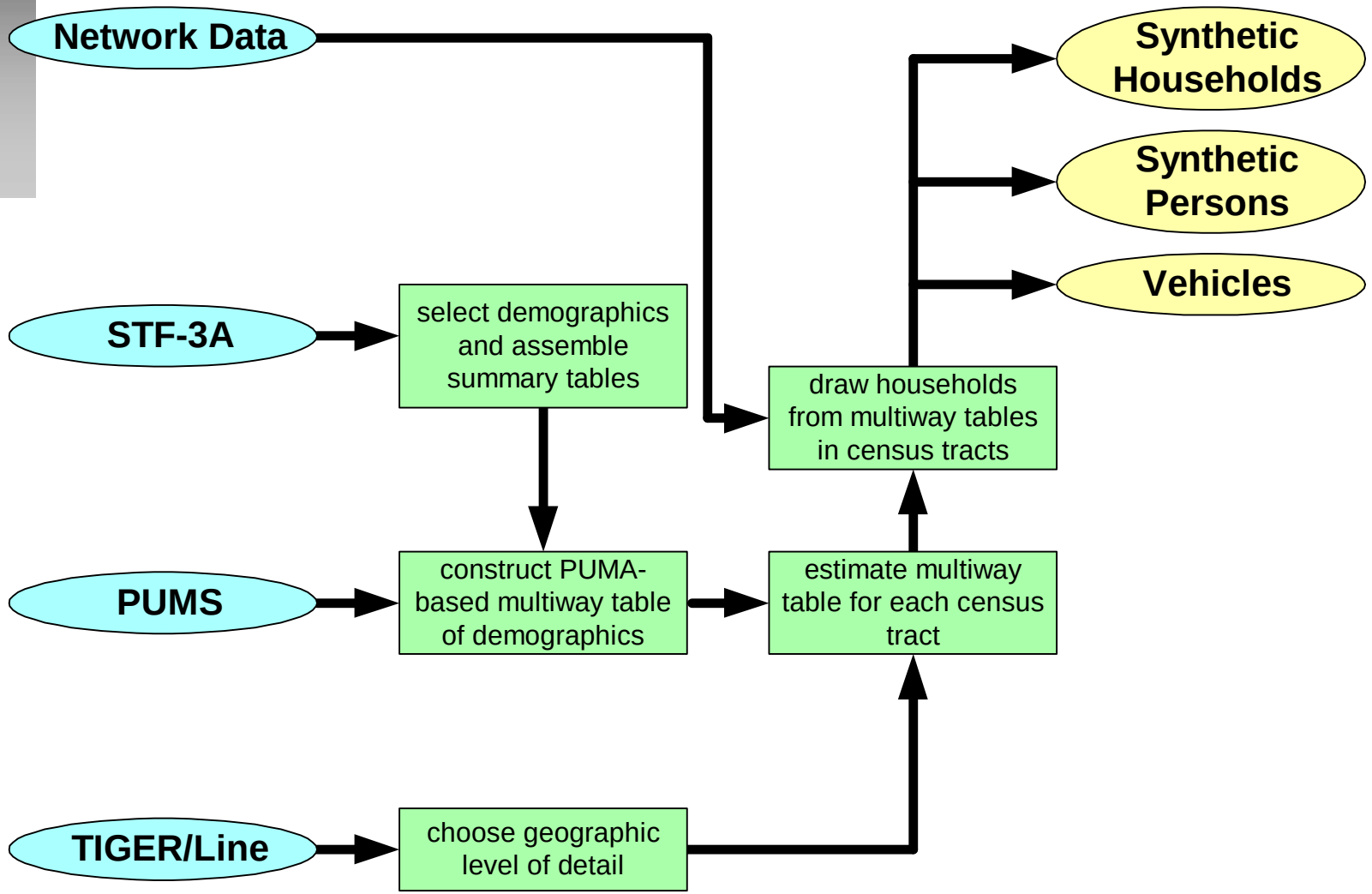
- *feedback is required to stabilize a nonlinear system*
- *the iteration process lets activities, route plans, and traffic converge to quasi-equilibrium*
- *some experiments/studies need to control the flow of information among TRANSIMS components between iterations*

Population Synthesizer

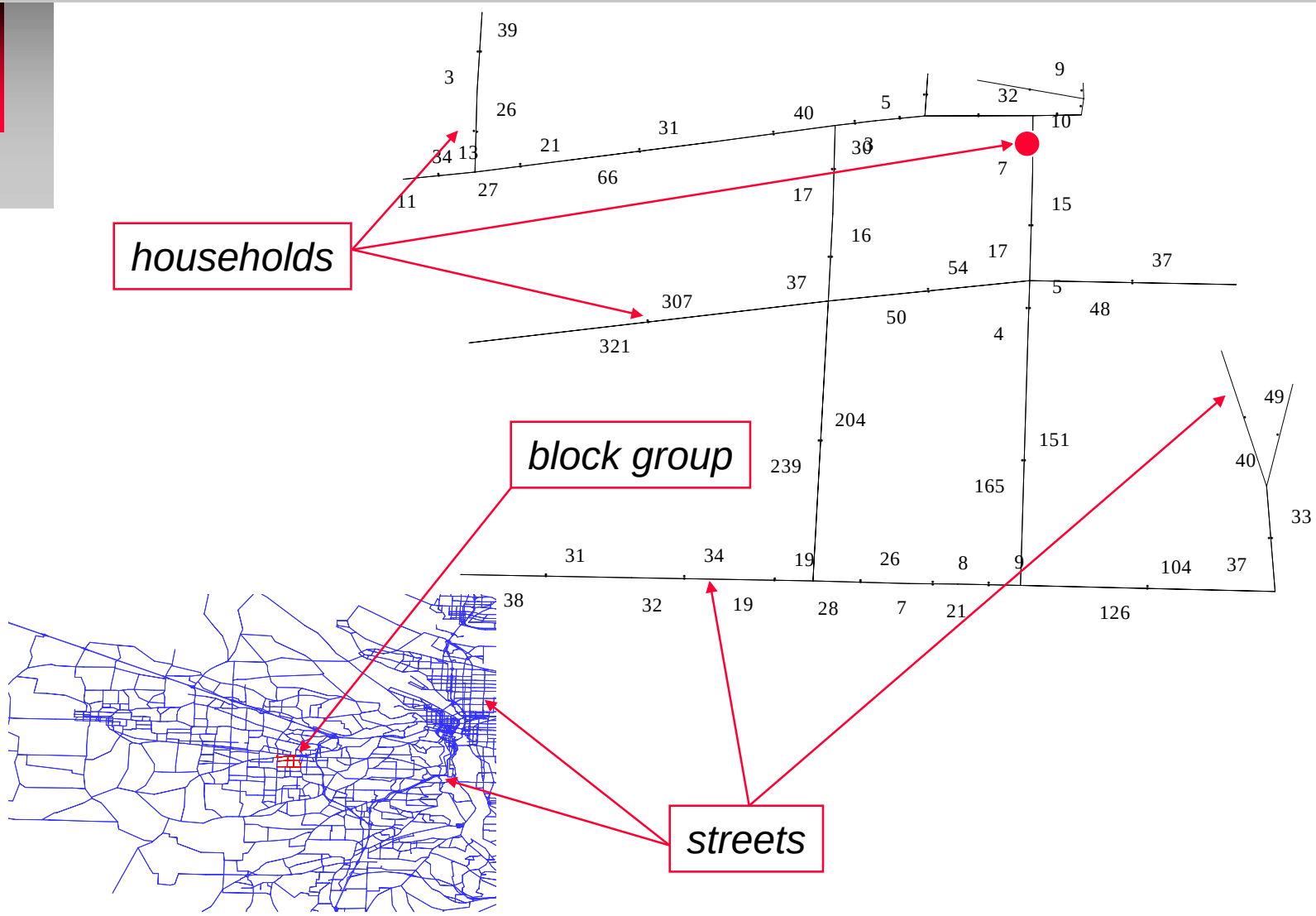
- *creates a regional population imitation*
  - *demographics closely match real population*
  - *households are distributed spatially to approximate regional population distribution*
- *synthetic population's demographics form basis for individual and household activities requiring travel*



Population Synthesizer: Algorithm

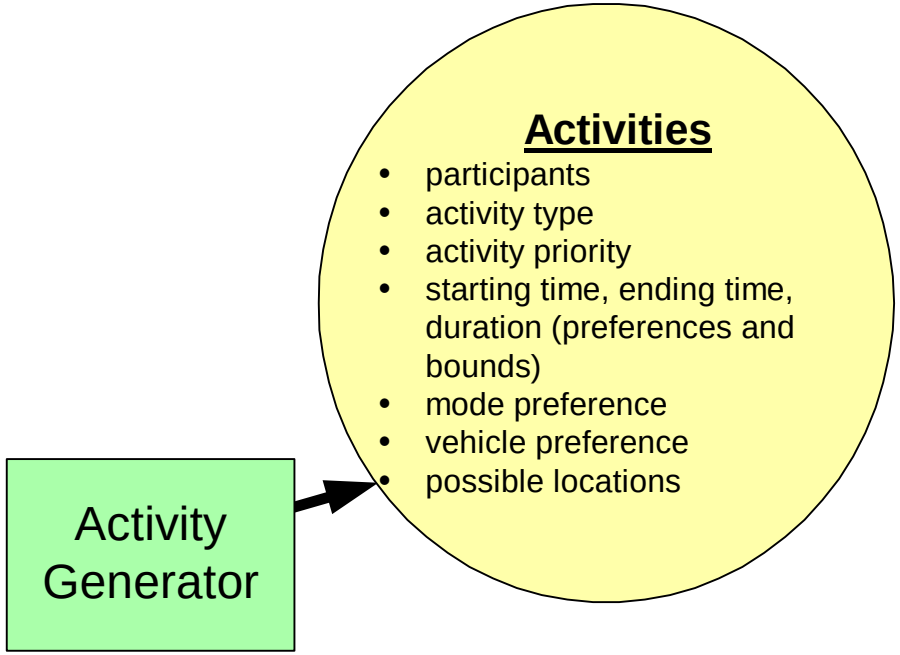


Example Block Group (#312002) in Portland, Oregon

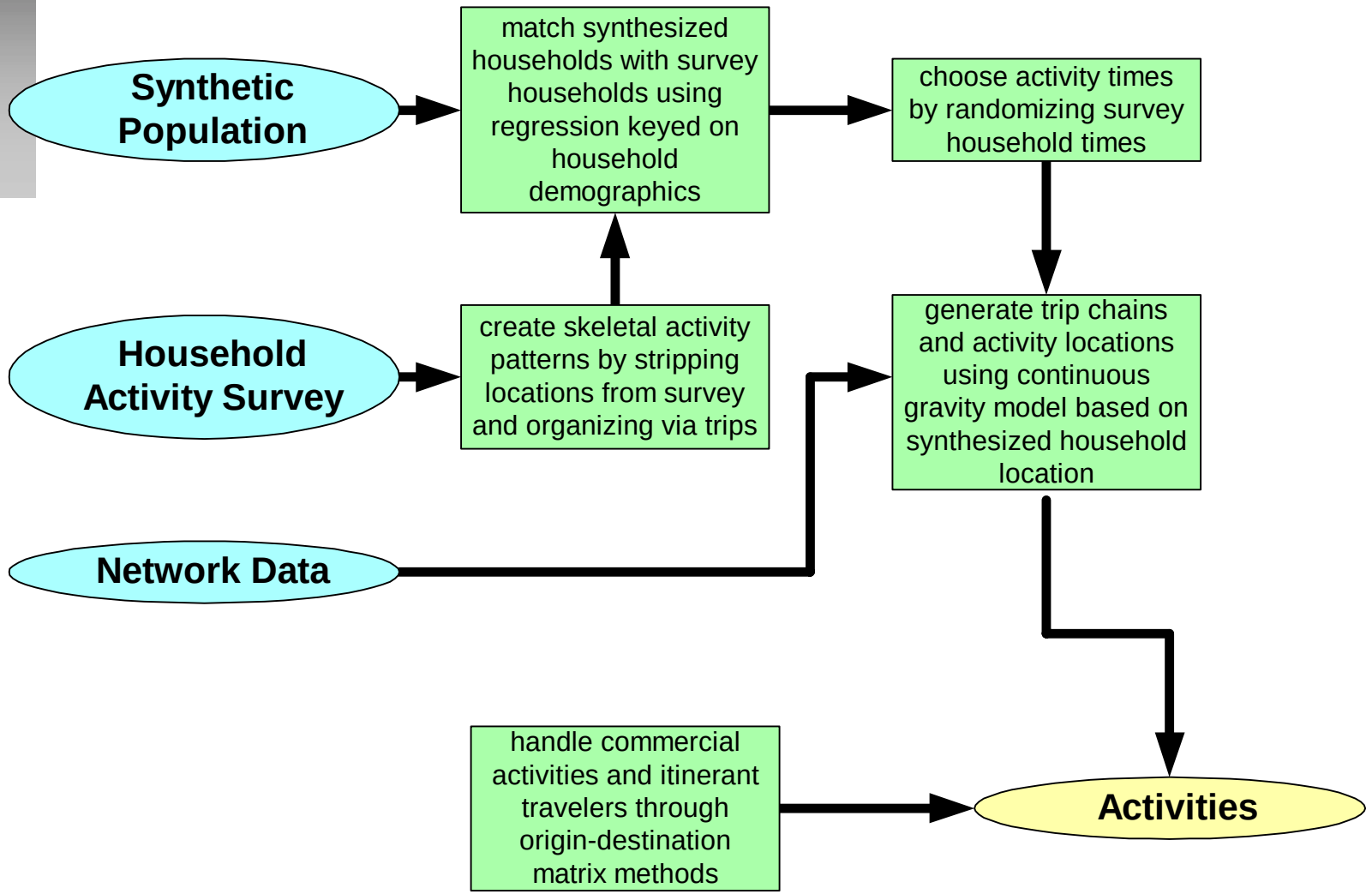


Activity Generator

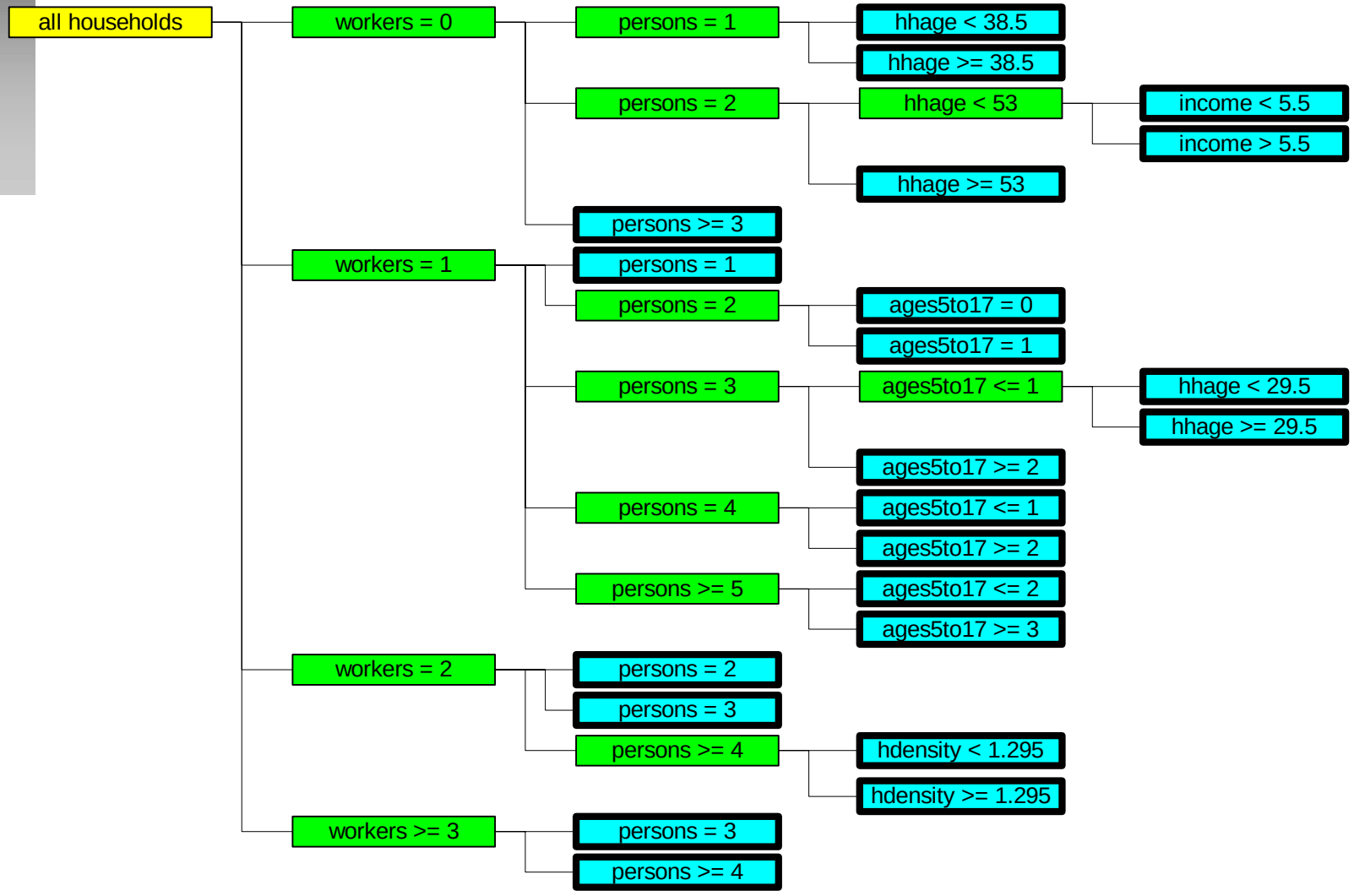
- *creates . . .*
  - *household and individual activities*
  - *activity priorities*
  - *activity locations*
  - *activity times*
  - *mode and travel preferences*
- *generates travel demand sensitive to demographics of synthetic population*
- *activities form basis for determining individuals' trip plans for the region*



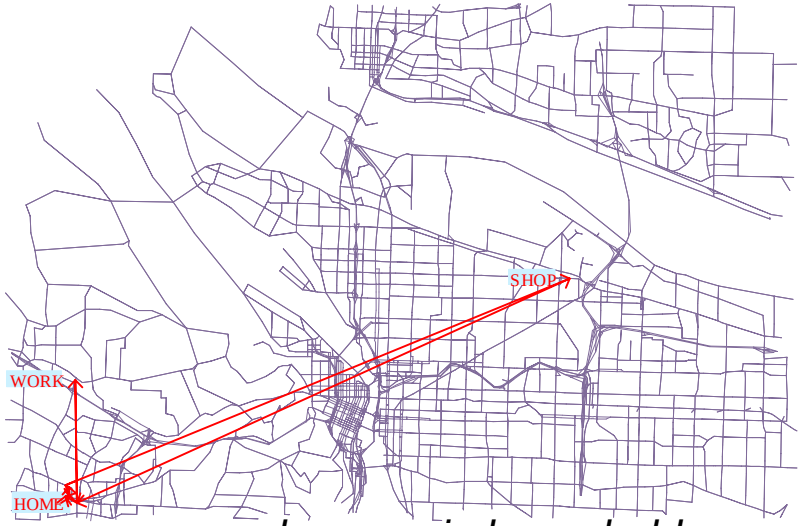
Activity Generator: Algorithm



Example Prediction Tree Using Household Demographics

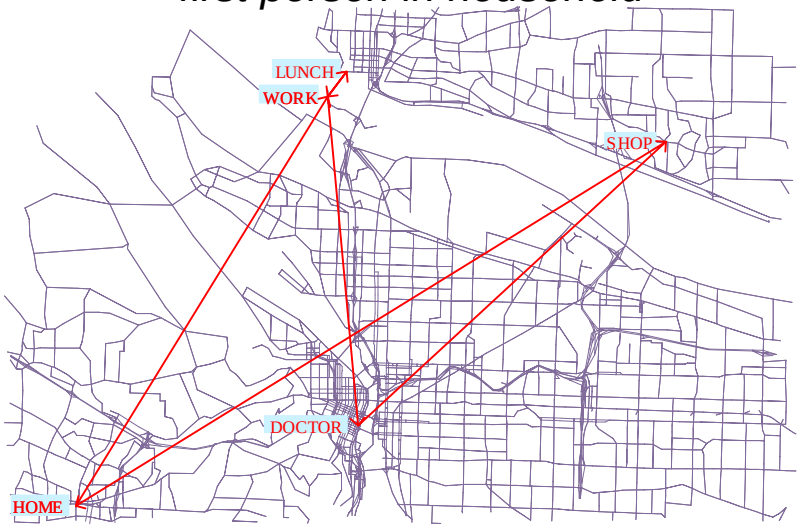


Example Activities in Portland, Oregon



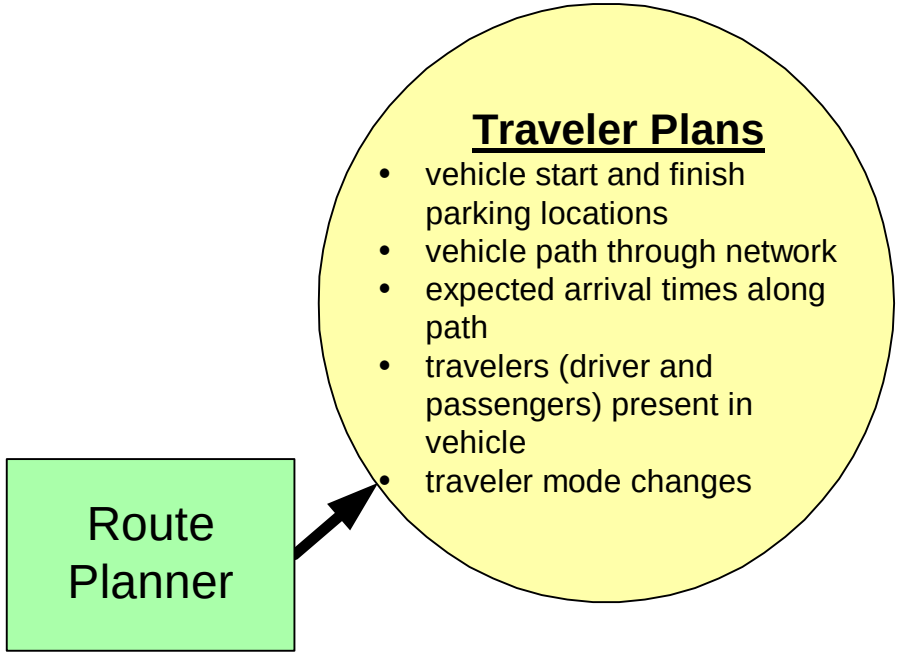
second person in household

first person in household

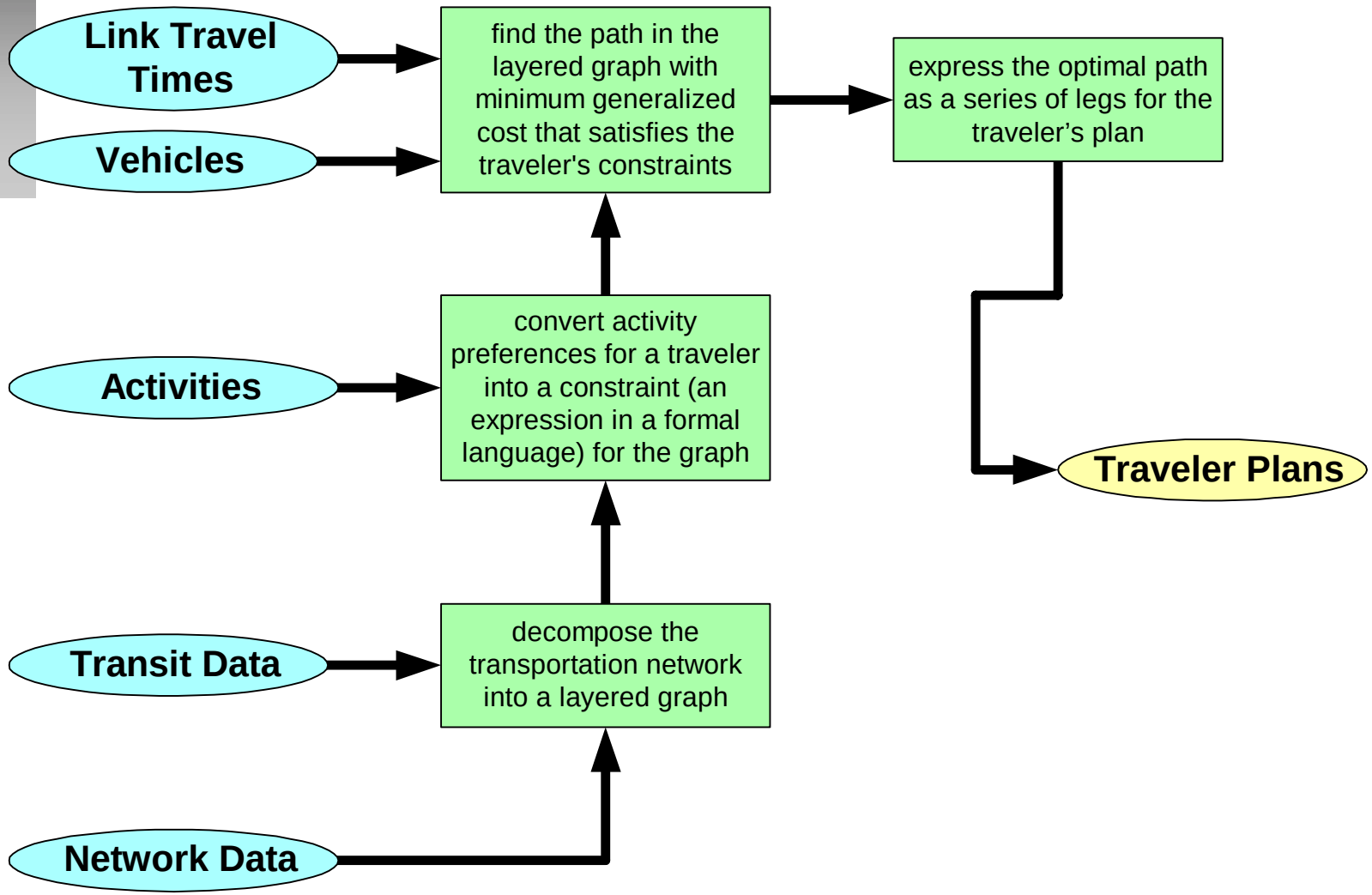


Route Planner

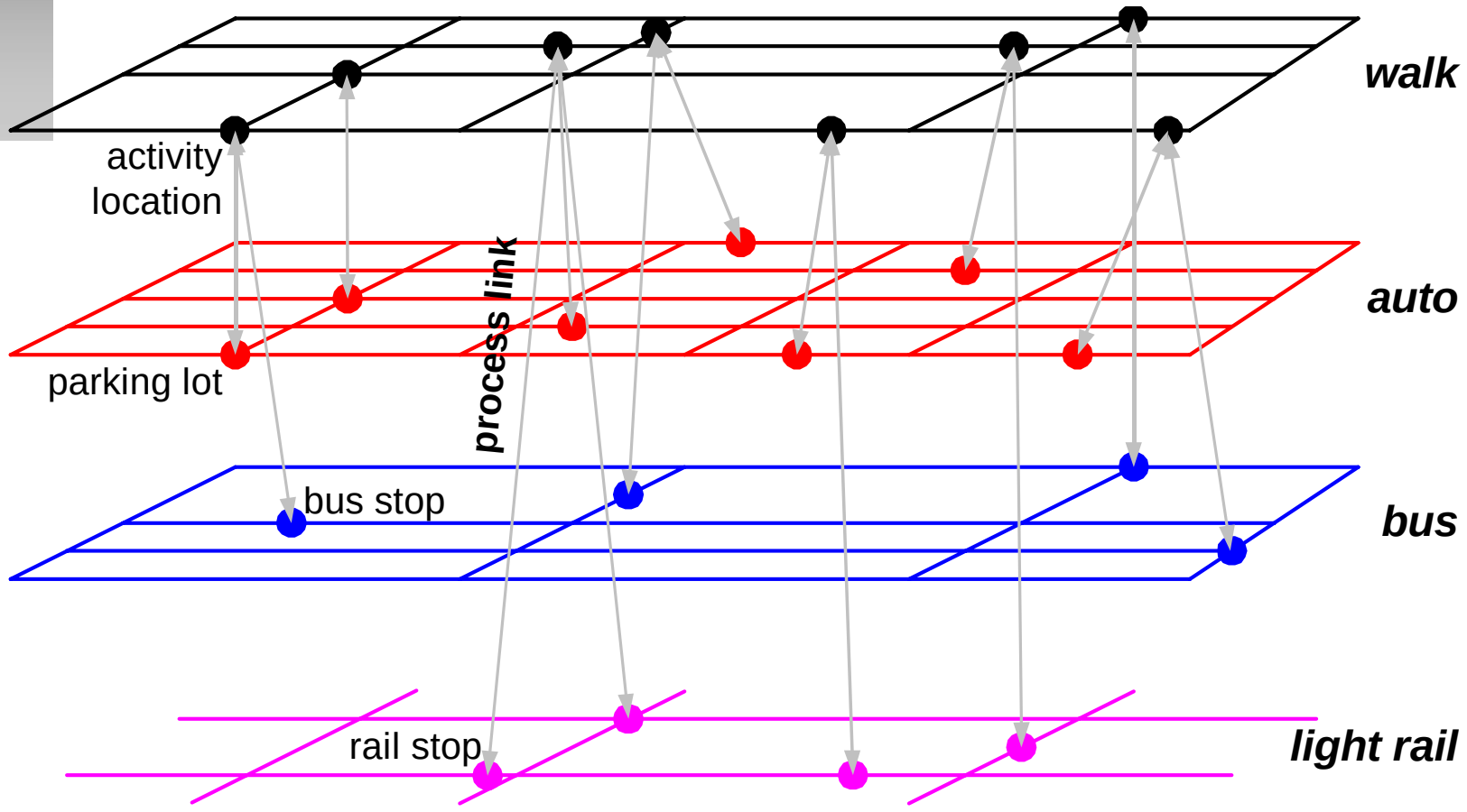
- *generates regional individual activity-based travel demand by assigning activities, modes, and routes to individuals in the form of trip plans*
- *trip plan selection related directly to each individual's goals*
- *individual trip plans form basis for traffic simulation that accounts for interactions among travelers*



Route Planner: Algorithm

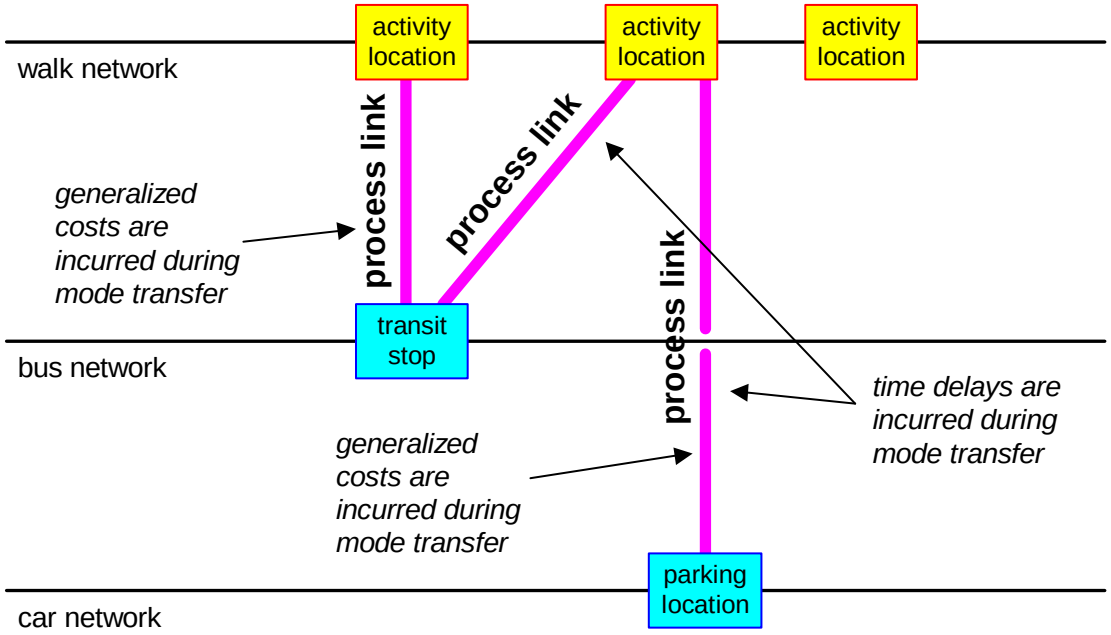


Example Layered Multi-Modal Network

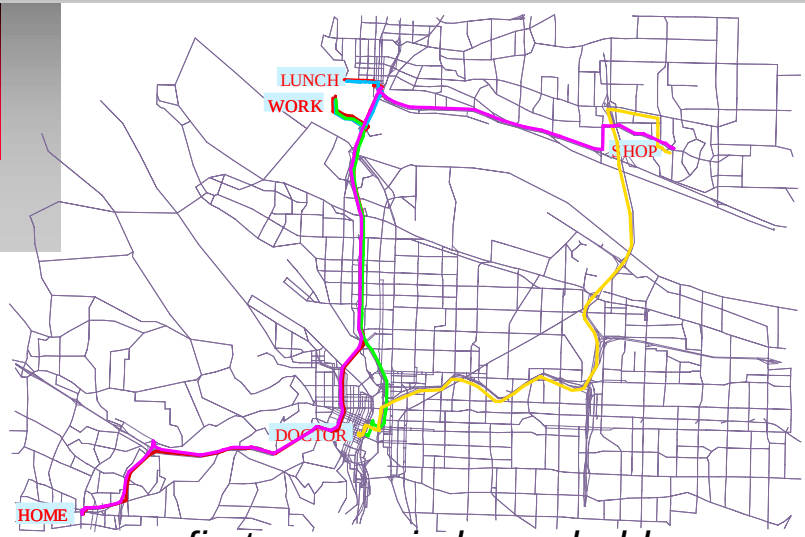


Formal Language for Mode Preferences

- *Symbols represent different modes:*
  - *w = "walk," c = "car," b = "bus," l = "light rail," t = (b|l) = "bus or light rail"*
- *A series of symbols expresses a mode preference:*
  - *wcw = "walk, then drive a car, then walk"*
  - *wctw = "walk, then drive to a transit stop, then take transit, then walk"*
  - *blb = "ride bus, then transfer to light rail, then ride bus"*
  - *w = "only walk"*
- *Each mode transfer passes through a process link where time and other costs are incurred.*

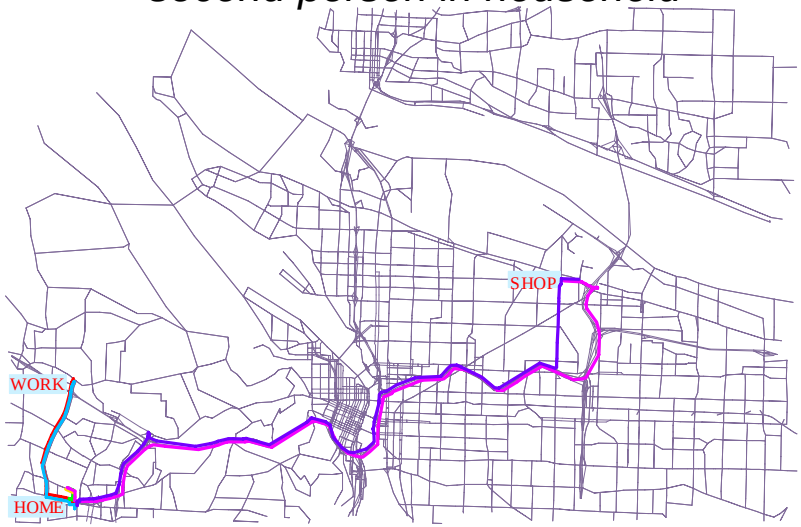


Example Route Plans in Portland, Oregon



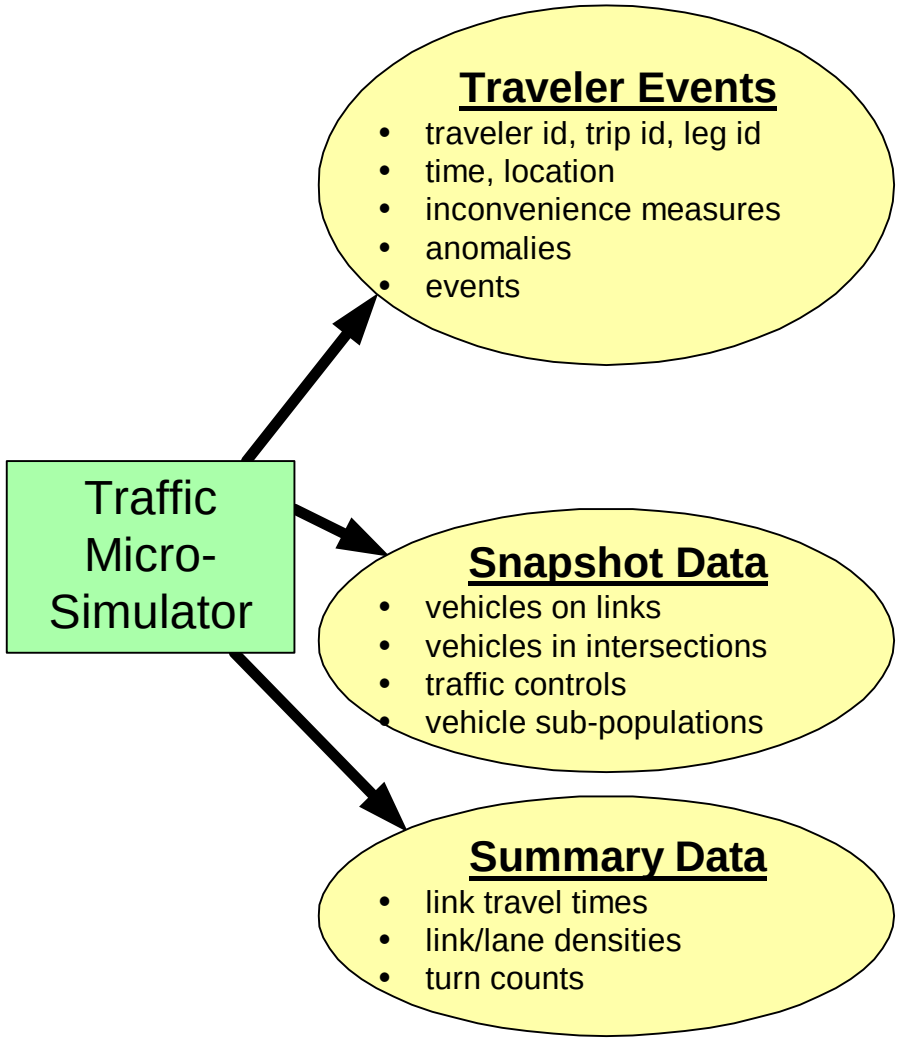
first person in household

second person in household

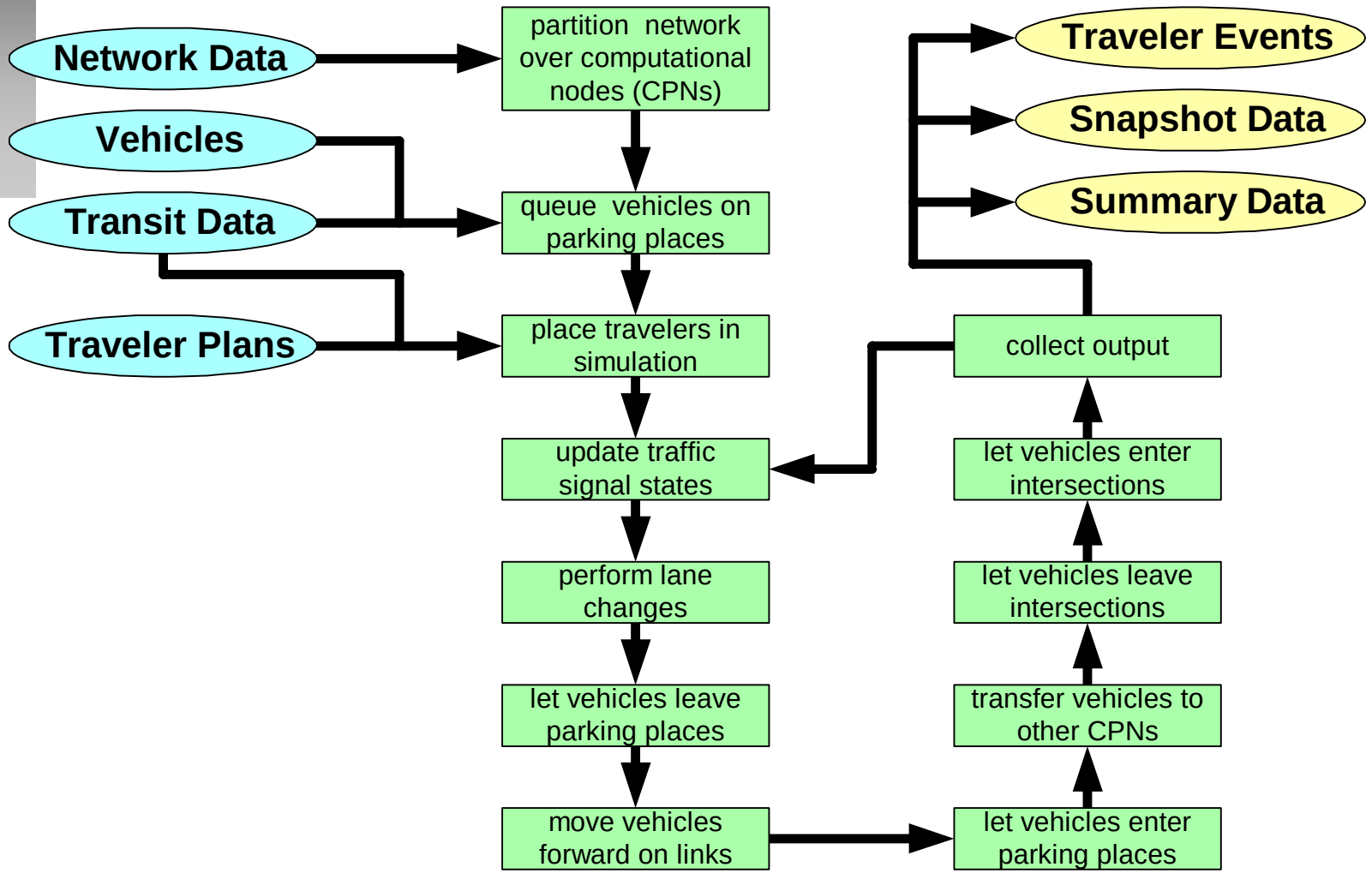


Traffic Microsimulator

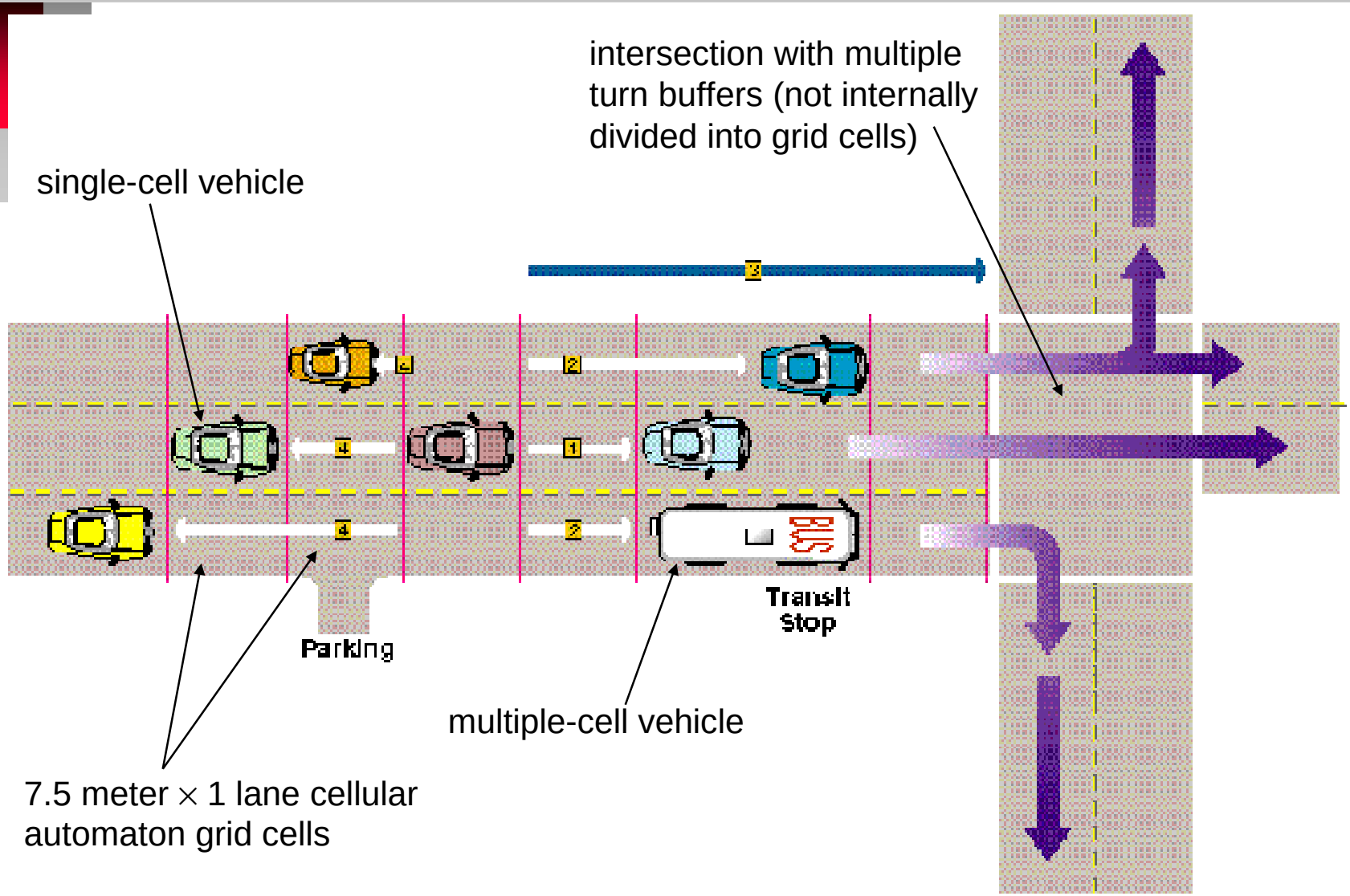
- *simulates the movement and interactions of travelers throughout a metropolitan region's transportation system*
  - *executes travel plans provided by the Route Planner*
  - *computes the overall intra- and inter-modal transportation system dynamics*
- *combined traveler interactions produce emergent behaviors (e.g., traffic congestion)*



Traffic Microsimulator: Algorithm

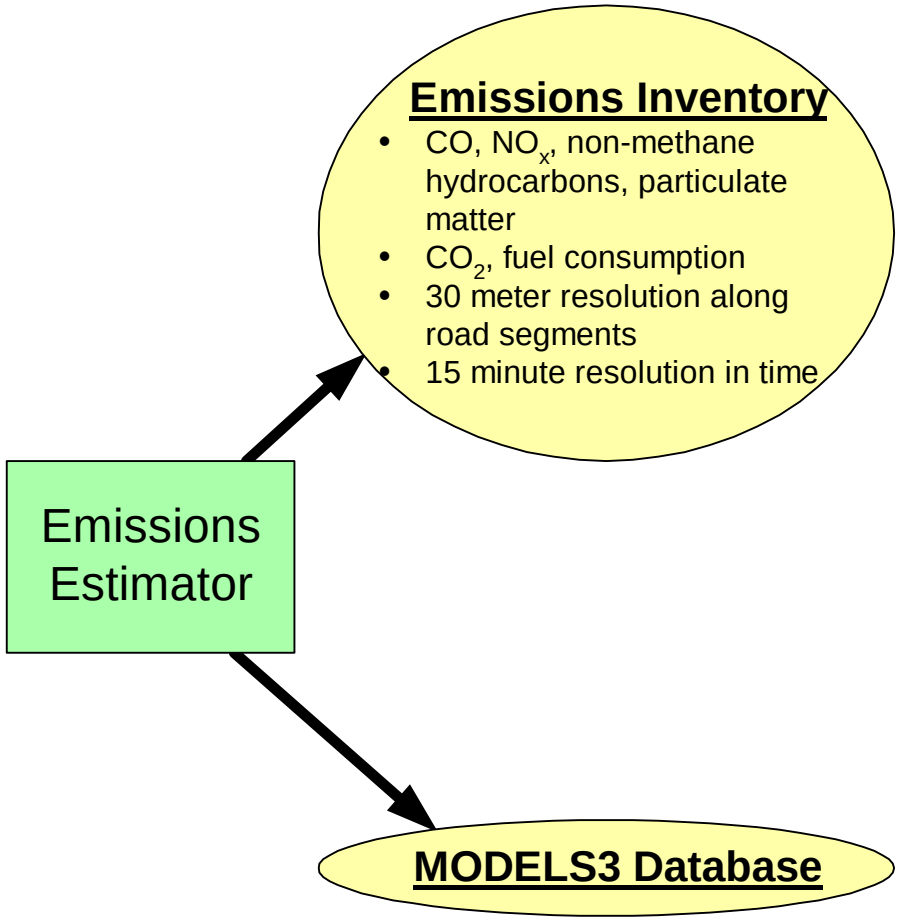


Cellular Automaton Microsimulation

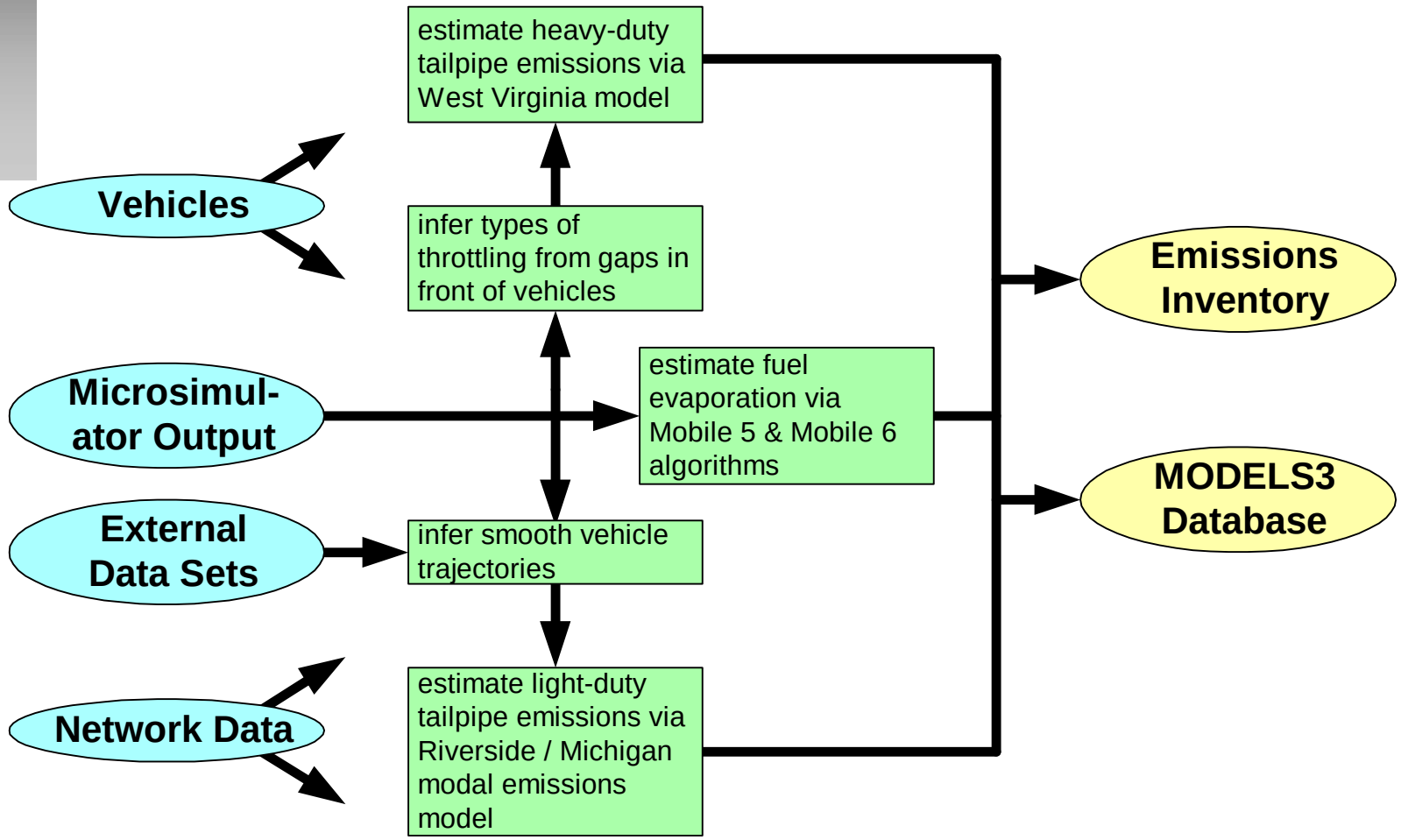


Emissions Estimator

- *translates traveler behavior into consequent . . .*
  - *air quality*
  - *energy consumption*
  - *pollutant emissions*
- *produces estimates of tailpipe and evaporative emissions for light- and heavy-duty vehicles as a function of vehicle . . .*
  - *fleet composition*
  - *status*
  - *dynamics*

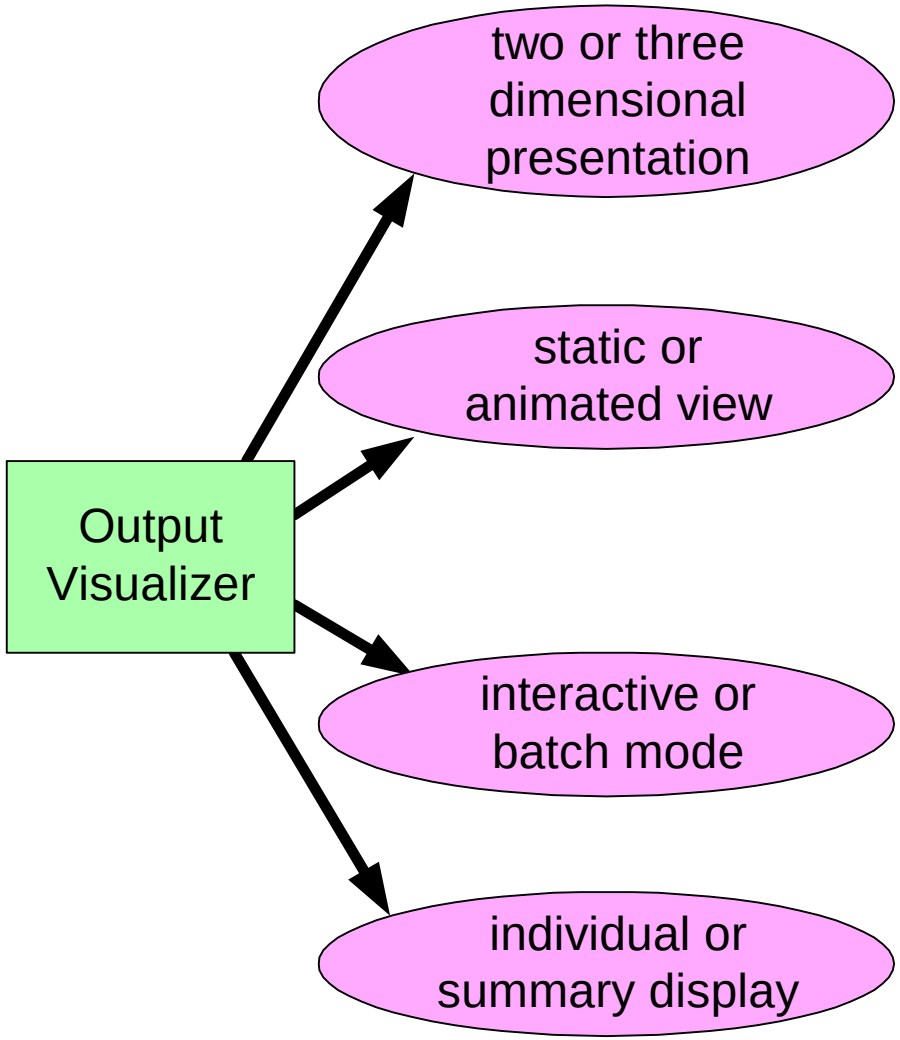


Emissions Estimator: Algorithm

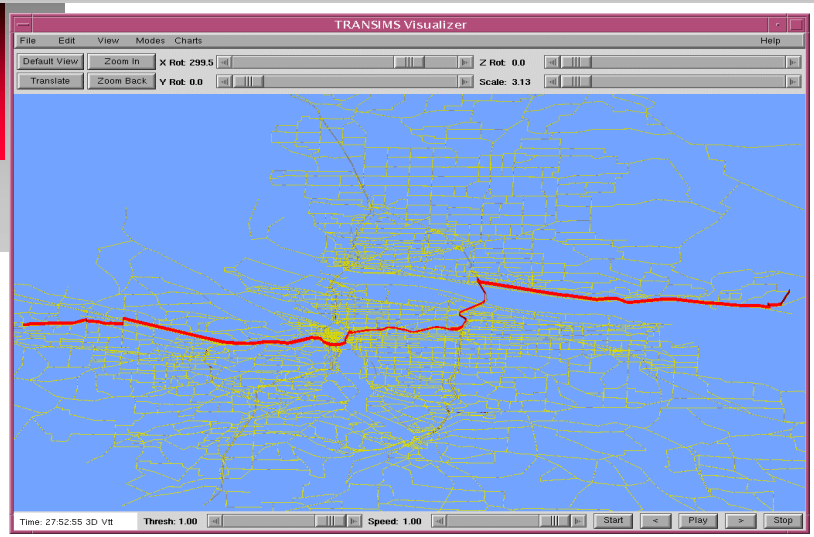


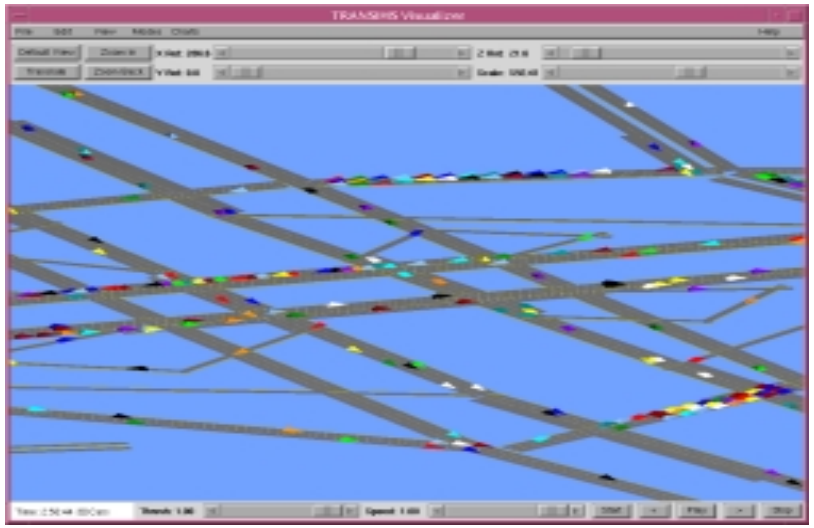
Output Visualizer

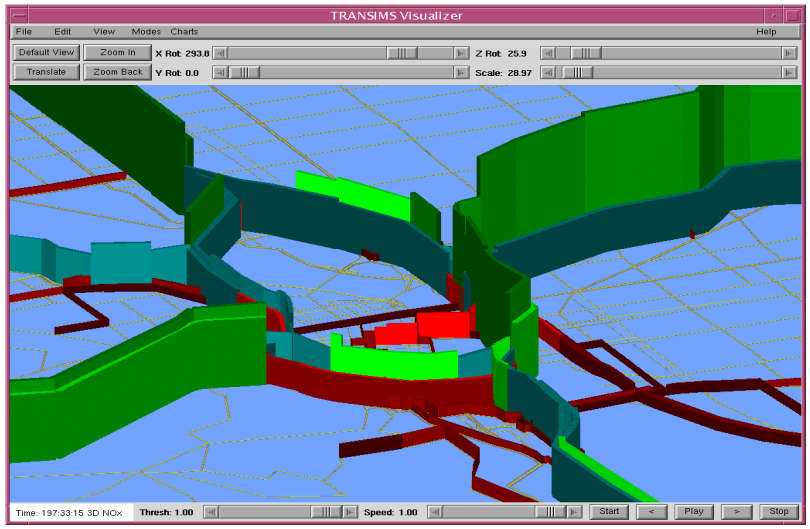
- *allows an analyst to view and animate data generated by any other TRANSIMS module*
- *provides a unified and flexible means for exploring the voluminous output data potentially available*

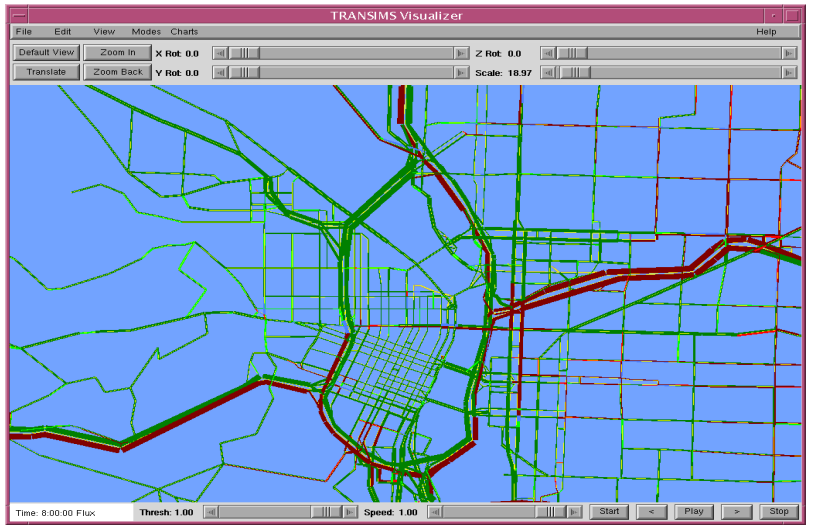


Example Output Visualization

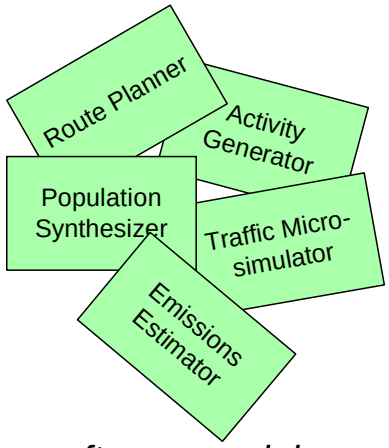




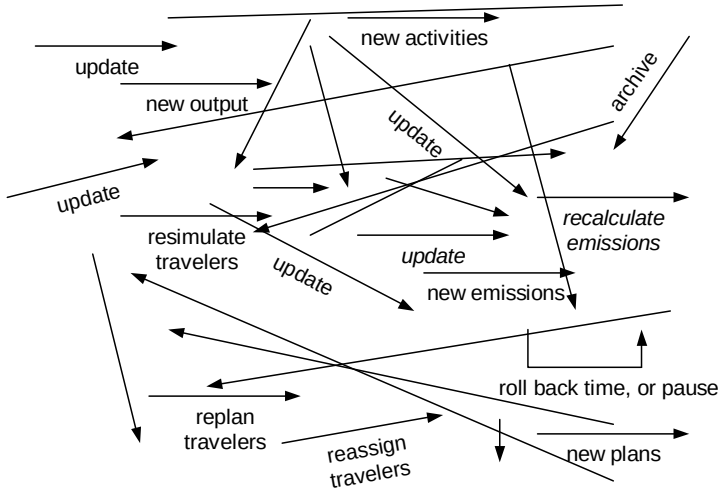




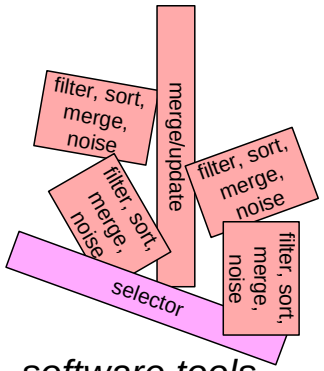
Building Blocks in the TRANSIMS Framework



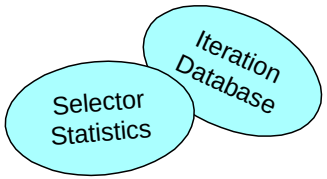
software modules



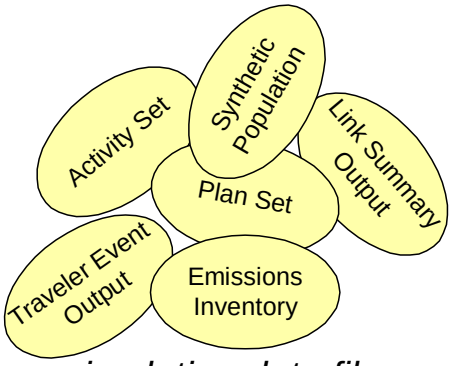
data flows



software tools

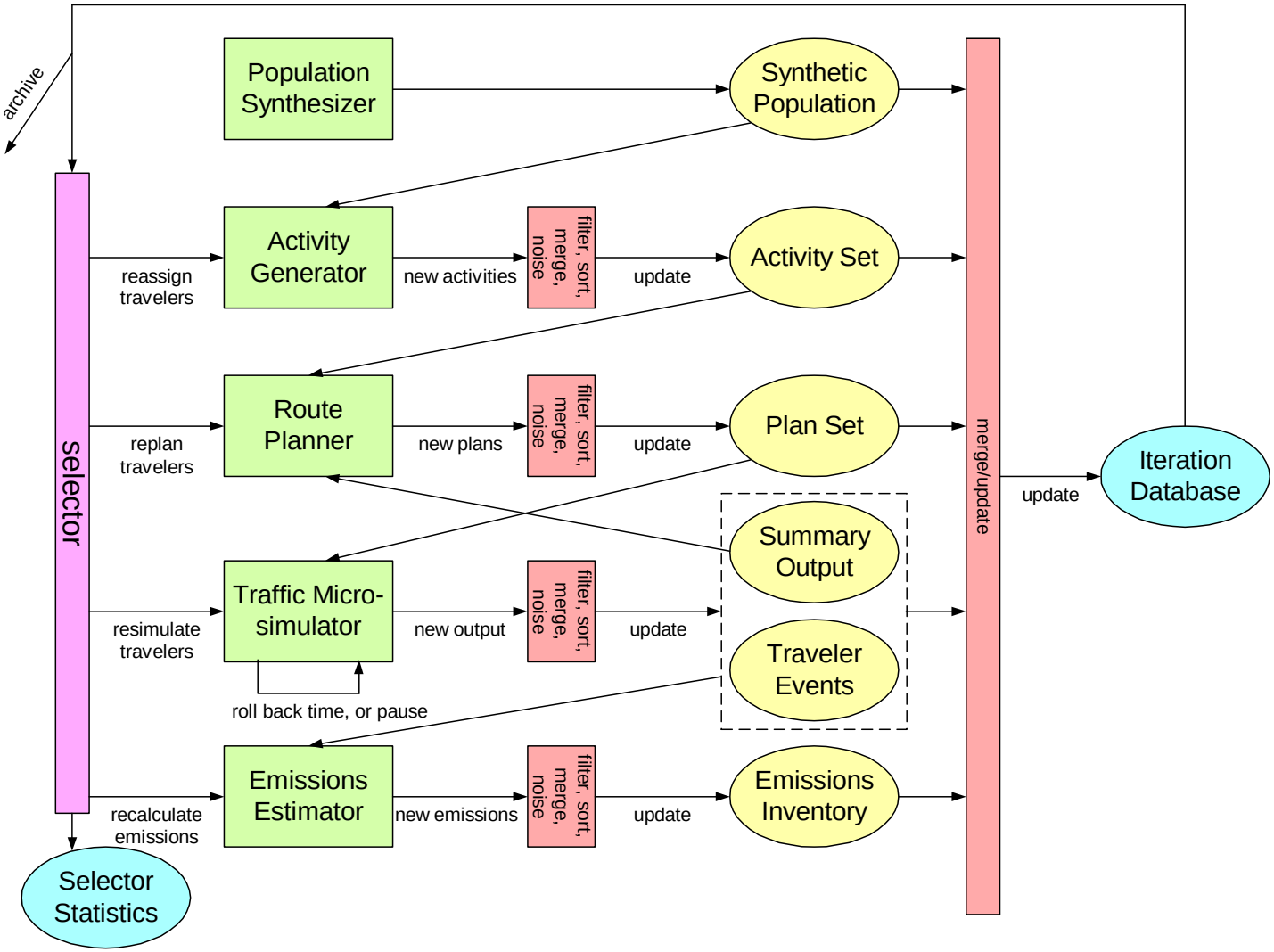


iteration data files

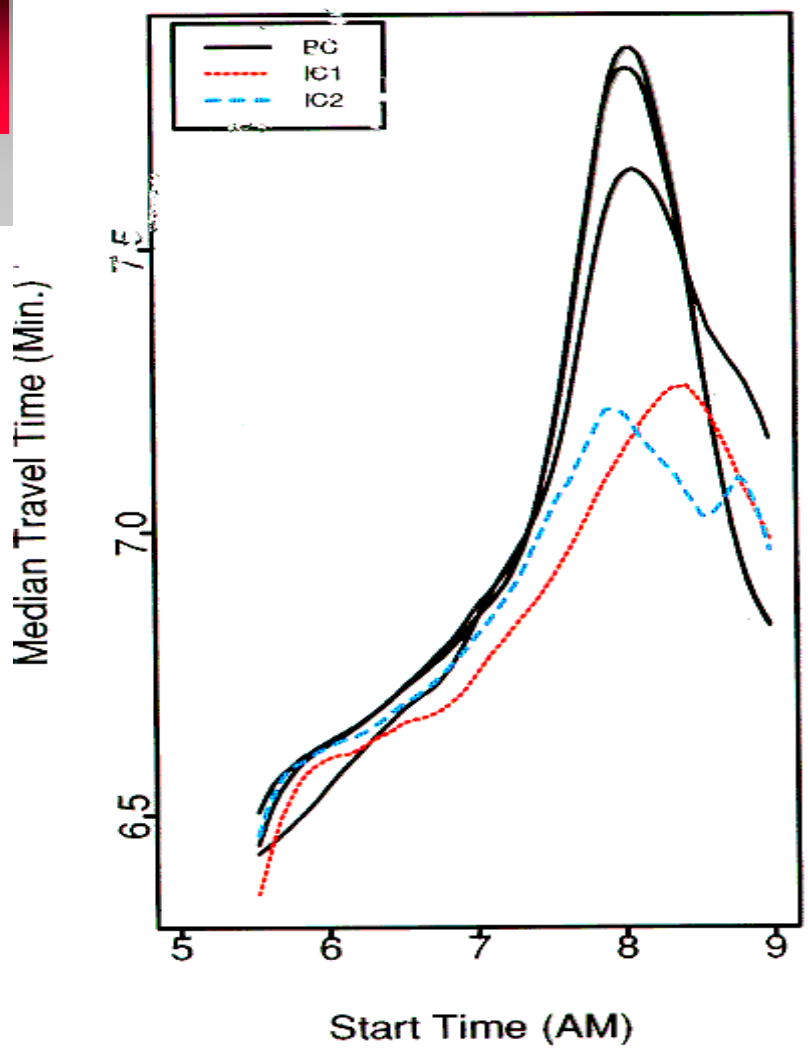


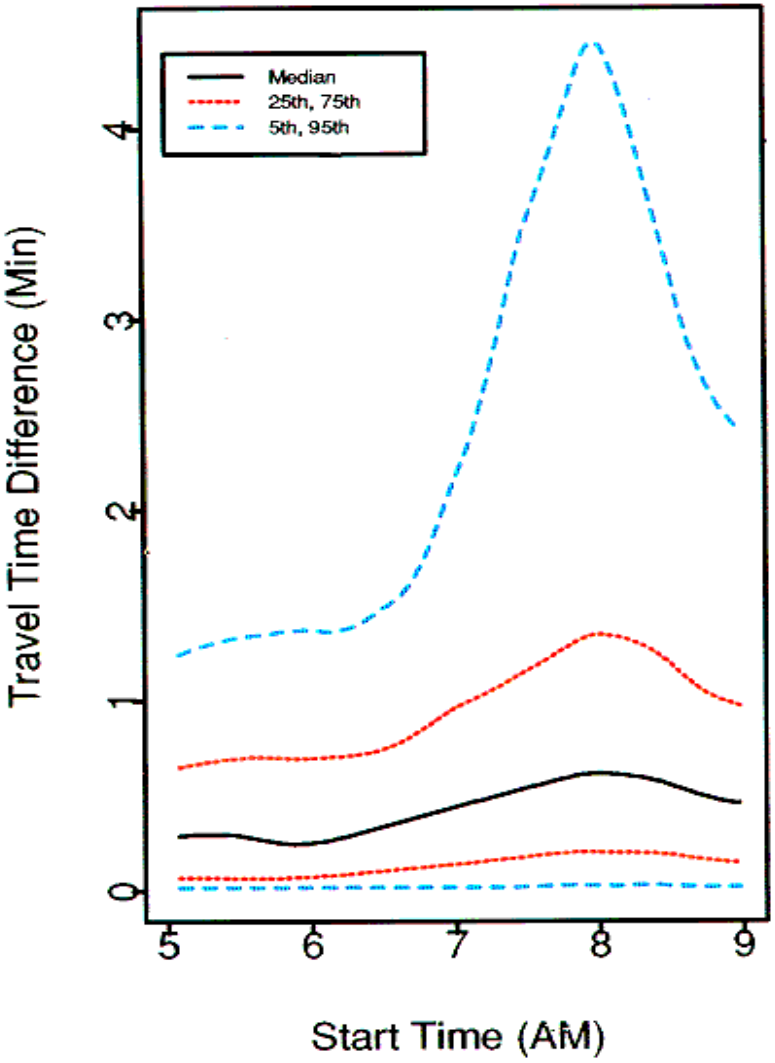
simulation data files

One Realization of TRANSIMS

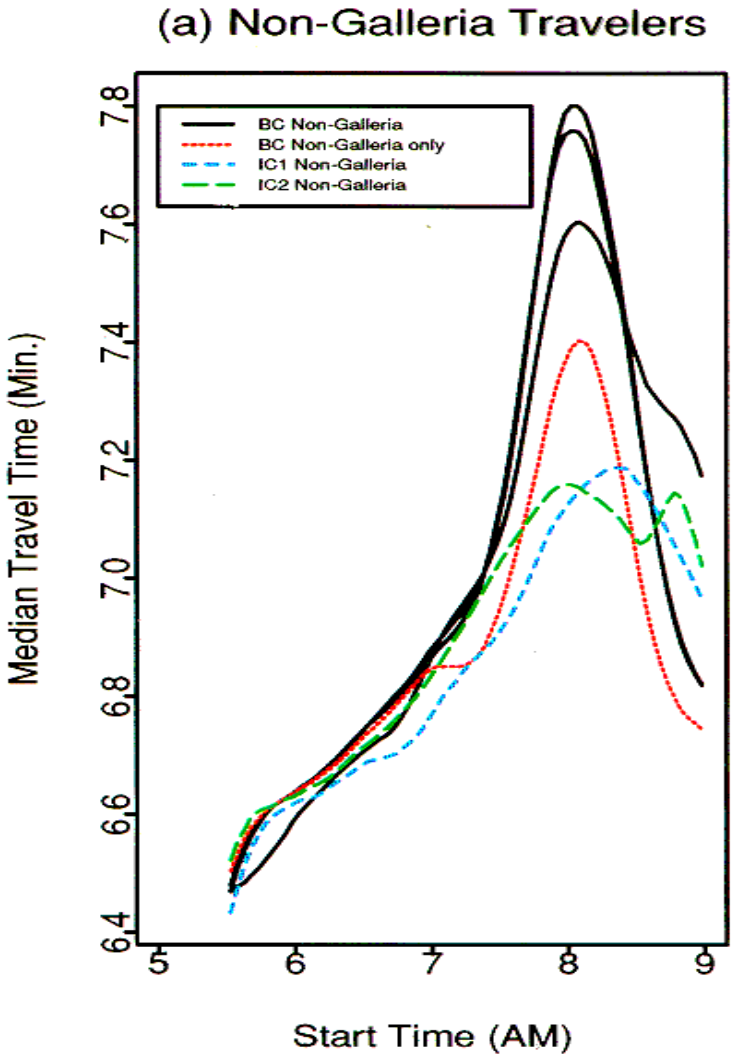


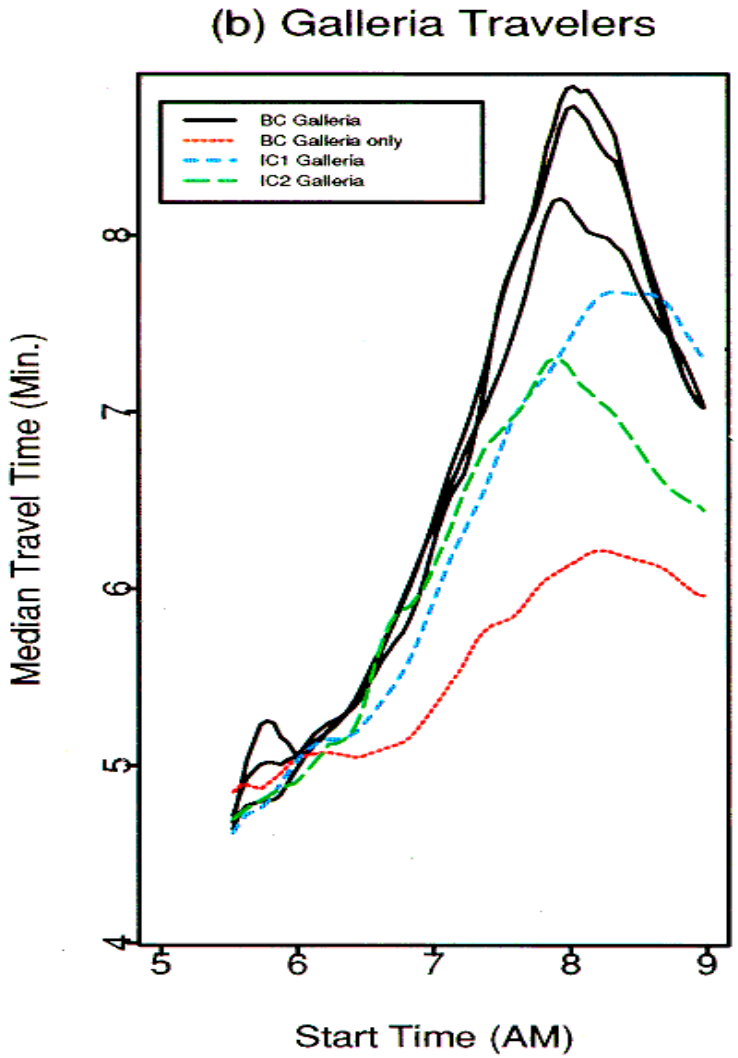
Infrastructure Comparison, Simulation Uncertainty, and Network Reliability



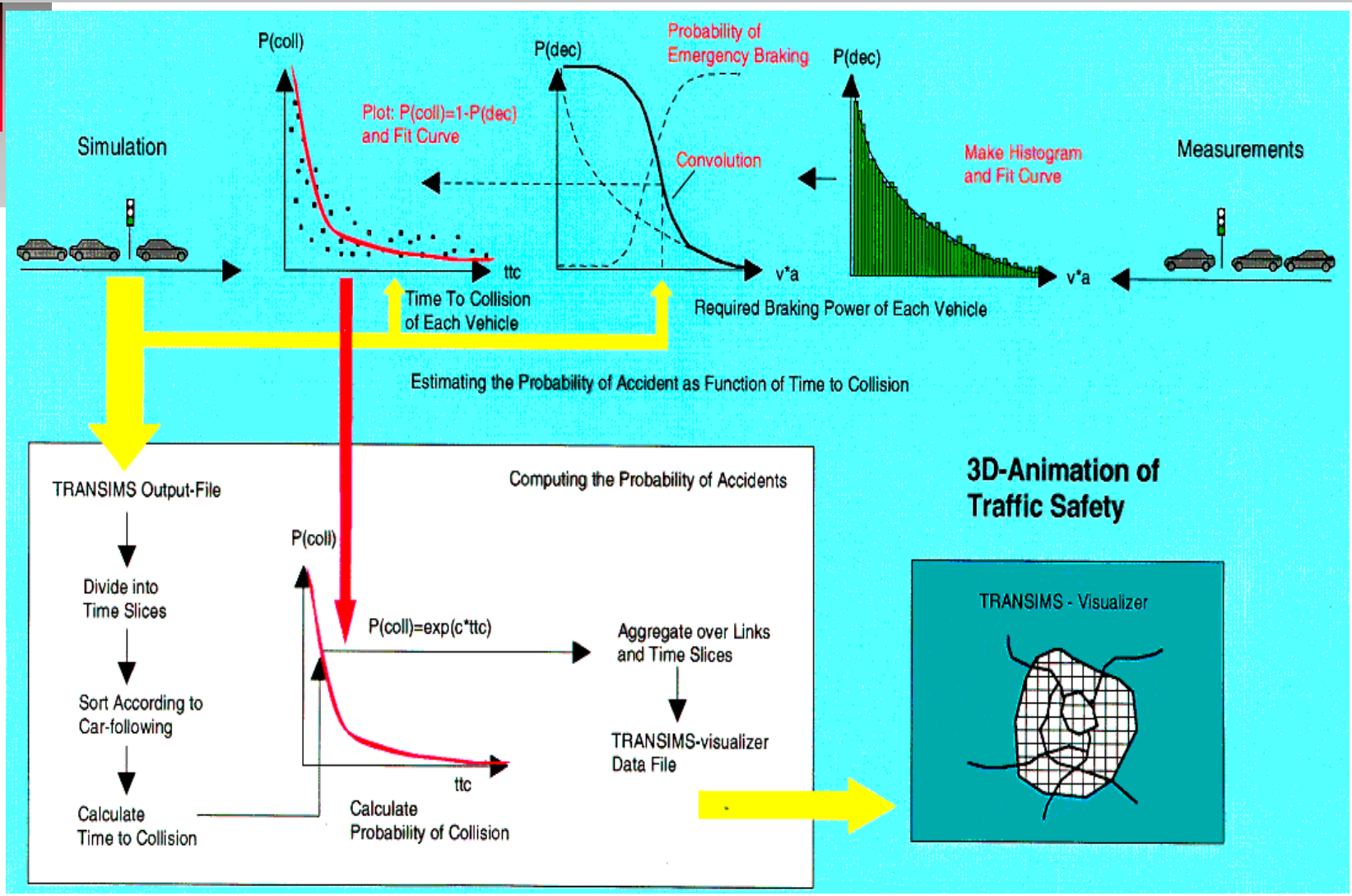


Equity Studies

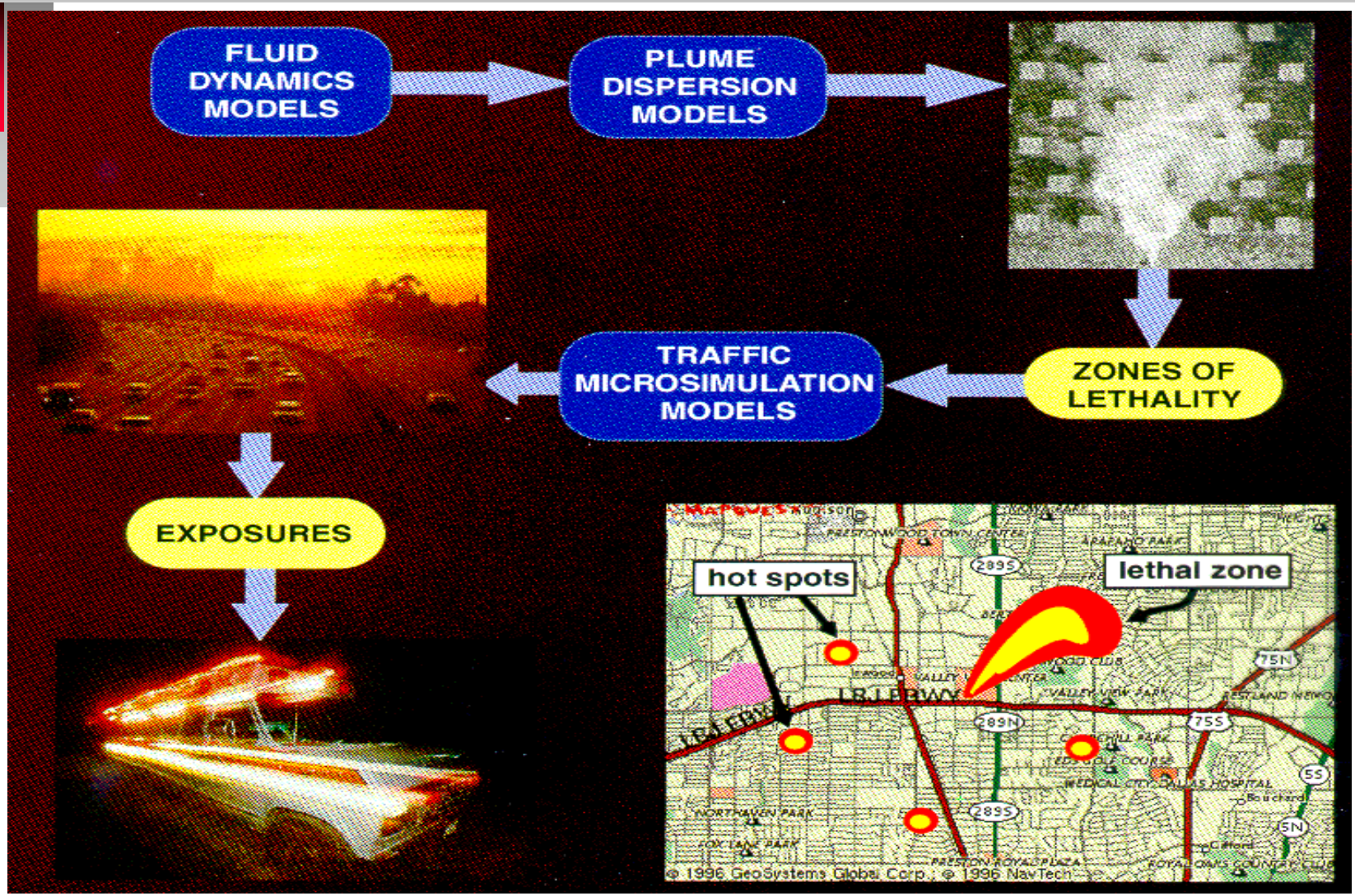




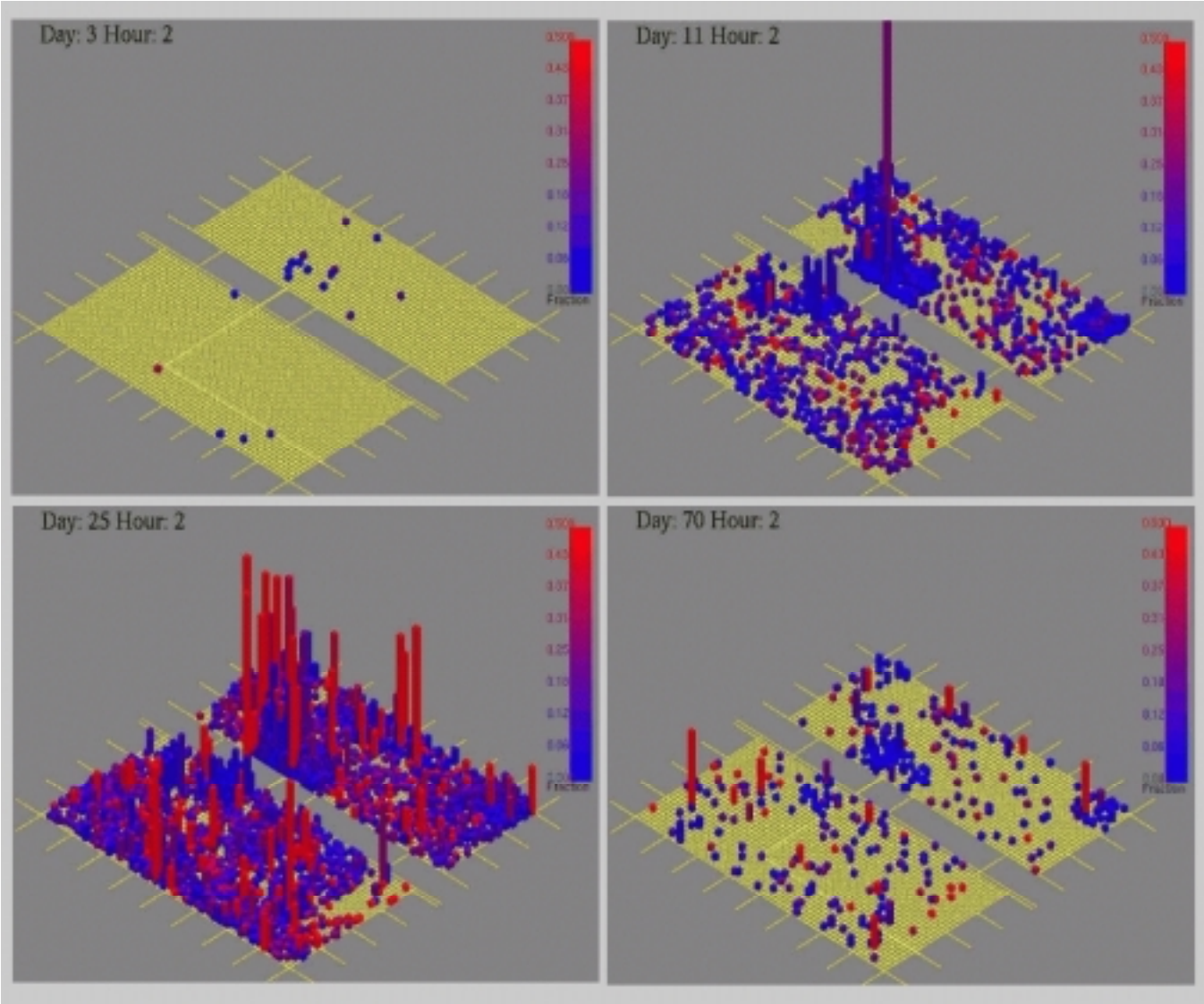
Simulation of Probability of Accidents



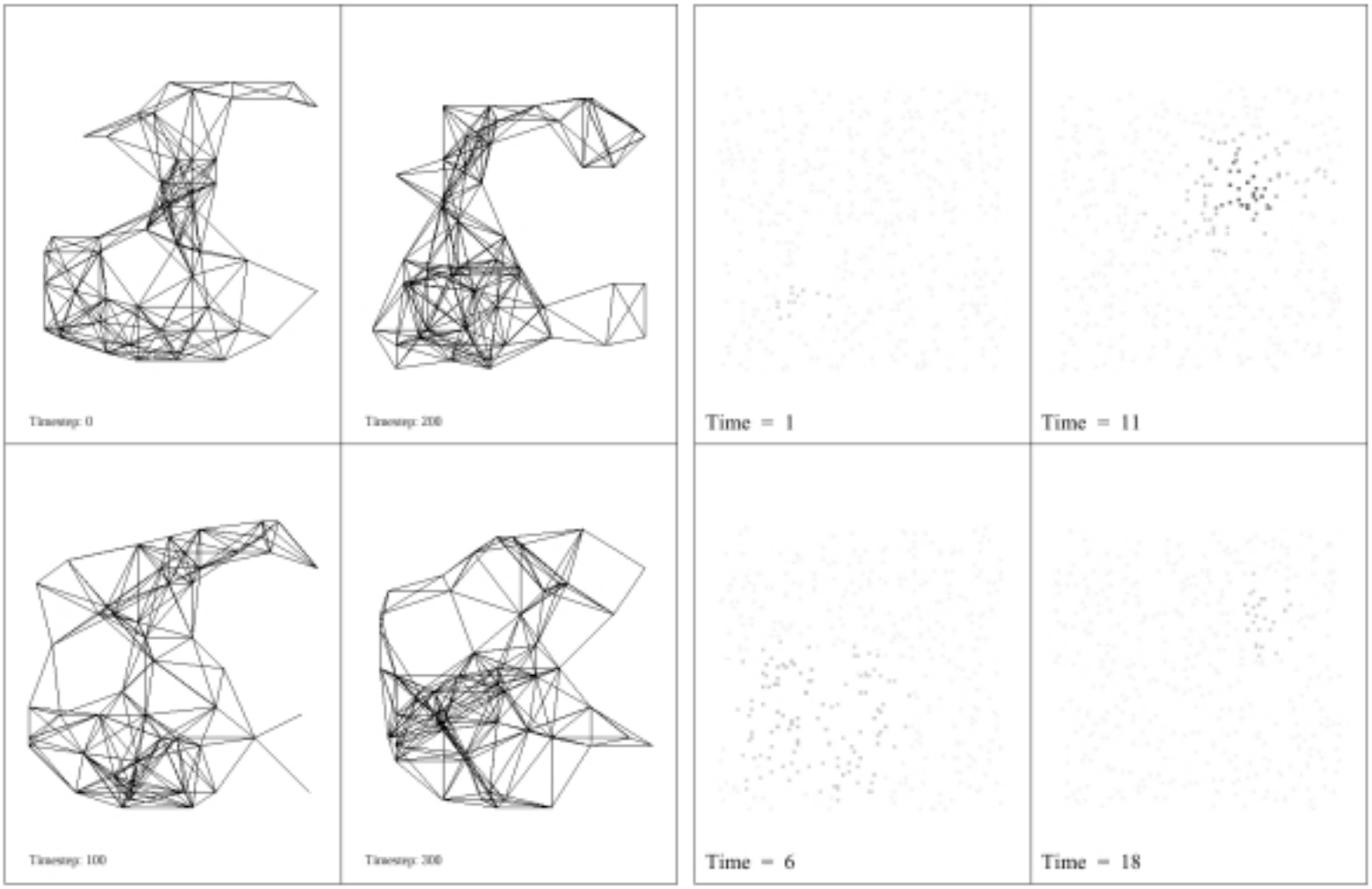
Urban Security: Airborne Toxic Release



Epidemic Simulation (EpiSims)



Ad-Hoc Communications Networks (MobiSim)



Ongoing and Future Research

- *computer science*
  - *parallel algorithms*
  - *large data set compression & distribution*
  - *pattern recognition*
  - *visualization*
  - *computational complexity and algorithms*
- *theory of simulation*
  - *sequential dynamical systems*
  - *dependency graphs*
  - *coupled/nested simulations*
- *complex systems*
  - *emergent behavior*
- *feedback studies*
  - *uses: convergence, stabilization, modeling*
  - *approaches: control theory, game theory, information theory*